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KING'S College LONDON

Calcification processes in cool temperature scleractinian corals.

Kinchington, D

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Volume 2 of 2

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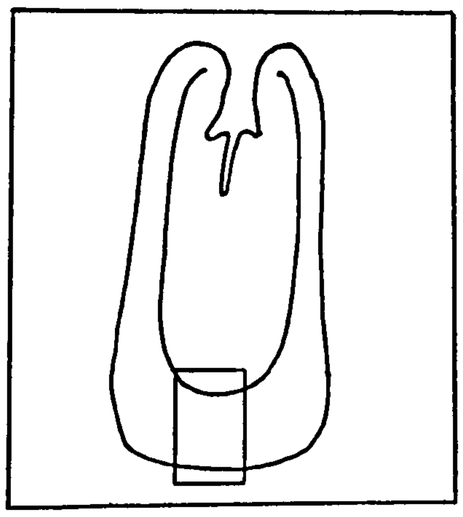
Figure 11

Vertical longitudinal section of the aboral region of a fully developed larva of Caryophyllia smithi showing epidermis, mesoglea, gastrodermis and a mesenterial filament.



The layered appearance of the cells along the distal margin of the epidermis is due to partial contraction of the tissues. Nematocysts (Ne) are common and they may be used by the larva to make temporary attachments with the substrate. Only a few interstitial cells (IC) are present. The apical free surface of the gastrodermis is lined with microvilli and each cell possesses a single cilium. Golgi complexes within the mesenterial filaments produce yolk-filled granules (YG); larger granules formed by the fusion of smaller ones are situated a short distance away.

The mesogleal Y-Junction, which indicates the origin of a mesentery, probably extends into the mesenterial filament which surmounts it (cf. Appendix B, Fig. 66).

AbE: aboral epidermis; Coel: coelenteron; Ga: gastrodermis; IC: interstitial cell; MFil: mesenterial filament; Ne: nematocyst; Nu: nucleus; V_1,V_2: Type 1 and Type 2 vesicles; YG: yolk granules.

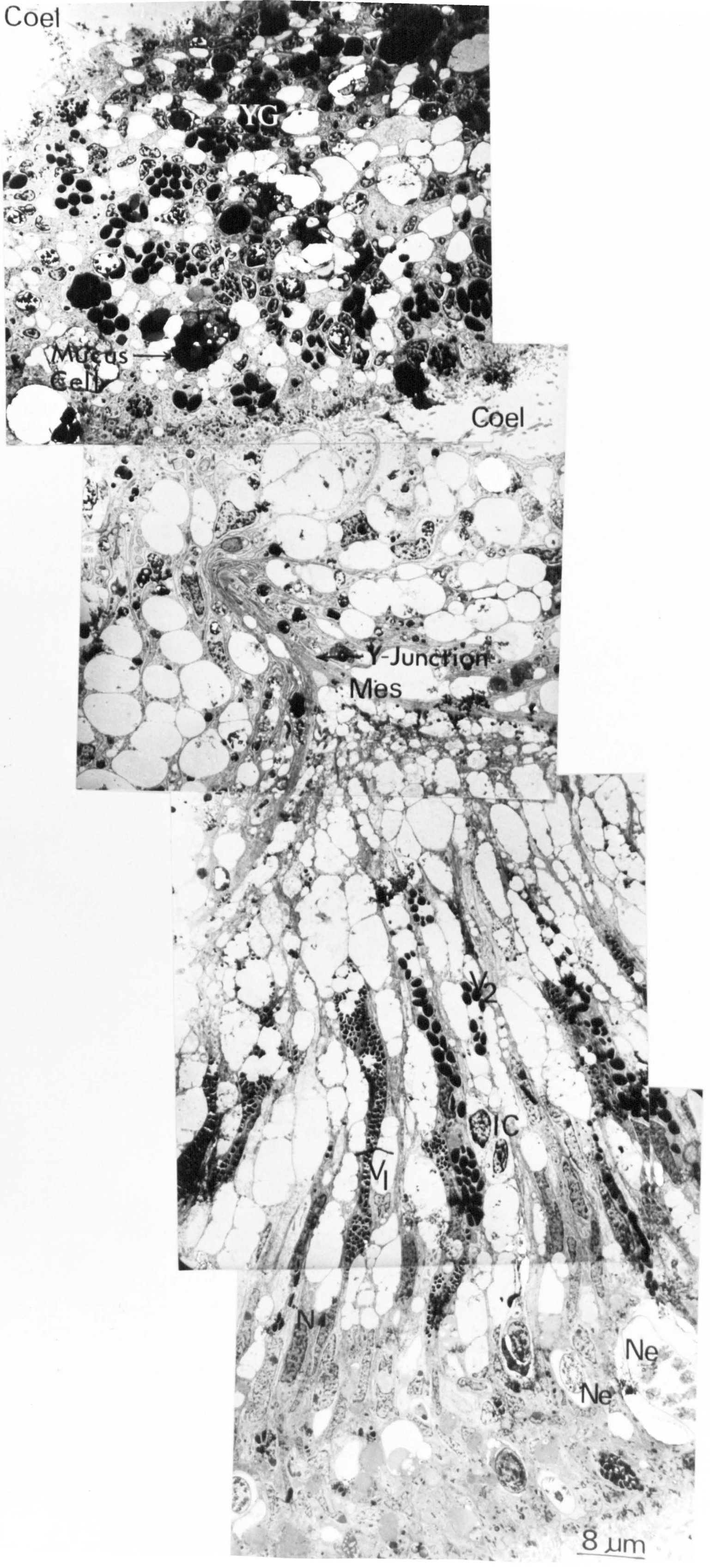
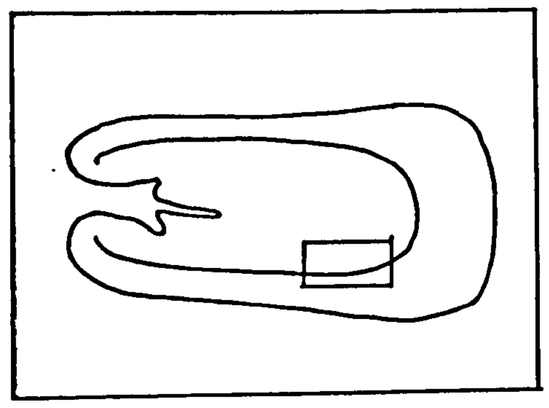

Coel
YG
Mucus Cell
Coel
Y-Junction
Mes
V2
IC
VI
N
Ne
Ne
8 µm
MFil
Ga
AbE

Figure 16

Vertical longitudinal section of the mesogleal region separating the gastrodermis and the aboral epidermis in a fully developed larva of Caryophyllia smithi.



The mesoglea is mostly acellular, probably of ectodermal origin, but a few amoeboid cells 3-5 µm in length are present within it. The processes of these cells (AC) are cigar shaped in section; their cytoplasm has a regular granular texture and darker staining bodies may be polysomes. Processes (Pr) from the epidermal and the gastrodermal cells appear as narrow bands, 0.5-1.5 µm in length, in the mesoglea. A few food vacuoles, similar to those in the gastrodermis, are present in the epidermis; it would appear that these food bodies are able to pass through the mesoglea.

AC: amoeboid cell; FV: food vacuoles; MF: microfilaments; M: mitochondrion; NP: neural processes; N: nucleus; Pr: epidermal and gastrodermal cell processes; Va: vacuoles; YG: yolk granules.

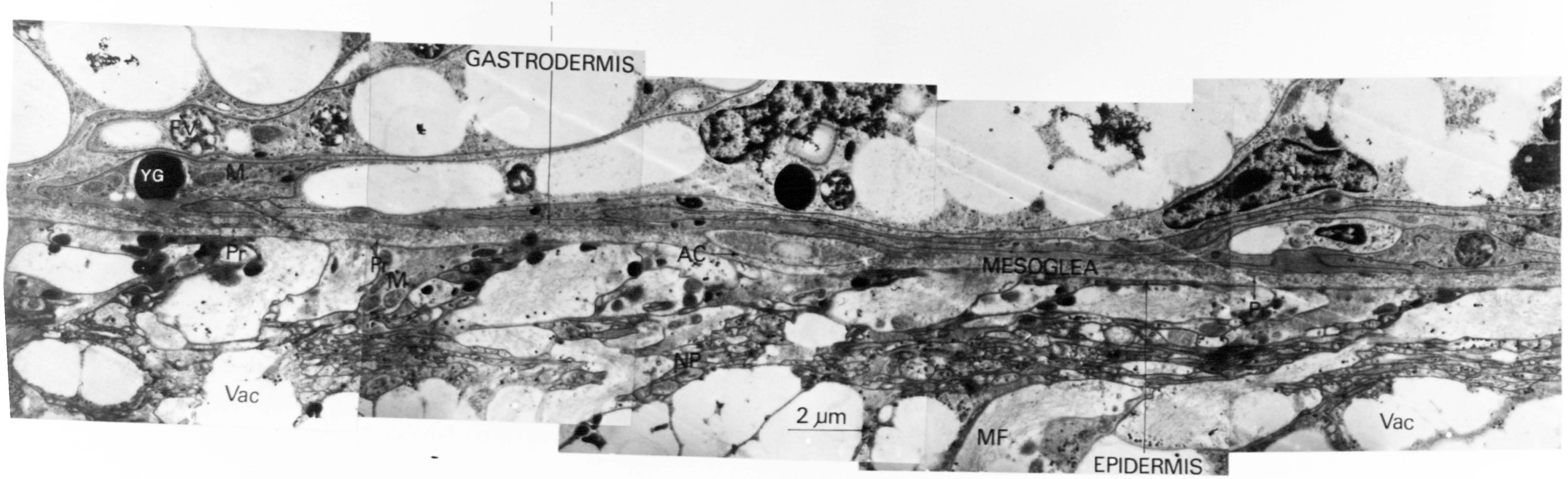
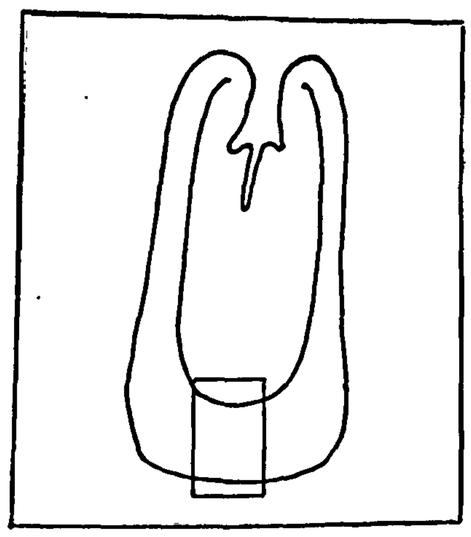

GASTRODERMIS
YG
M
Pr
Pr
M
AC
NP
MESOGLEA
Vac
2 µm
MF
EPIDERMIS
Vac

Figure 17

Vertical longitudinal section of the aboral region of a newly released larva (1-12 hour) of Balanophyllia regia showing four types of gland cells.



The width of the epidermis, from the mesoglea to the distal margin, is approximately 100 μm. Reorganisation of the proximal region, which is 10-15 μm in width (PR), appears to be occurring: neurites and plasma membranes are not easily distinguishable. Type 1 gland cells are the most common at this stage of larval development.

AE: aboral epidermis; FV: food vacuole; Ga: gastrodermis; Li: lipid; Mes: mesoglea; N: nucleus; Ne: nematocyst; PR: proximal region; V_1,V_2,V_3,V_4: vesicle Types 1-4; Li: lipid.

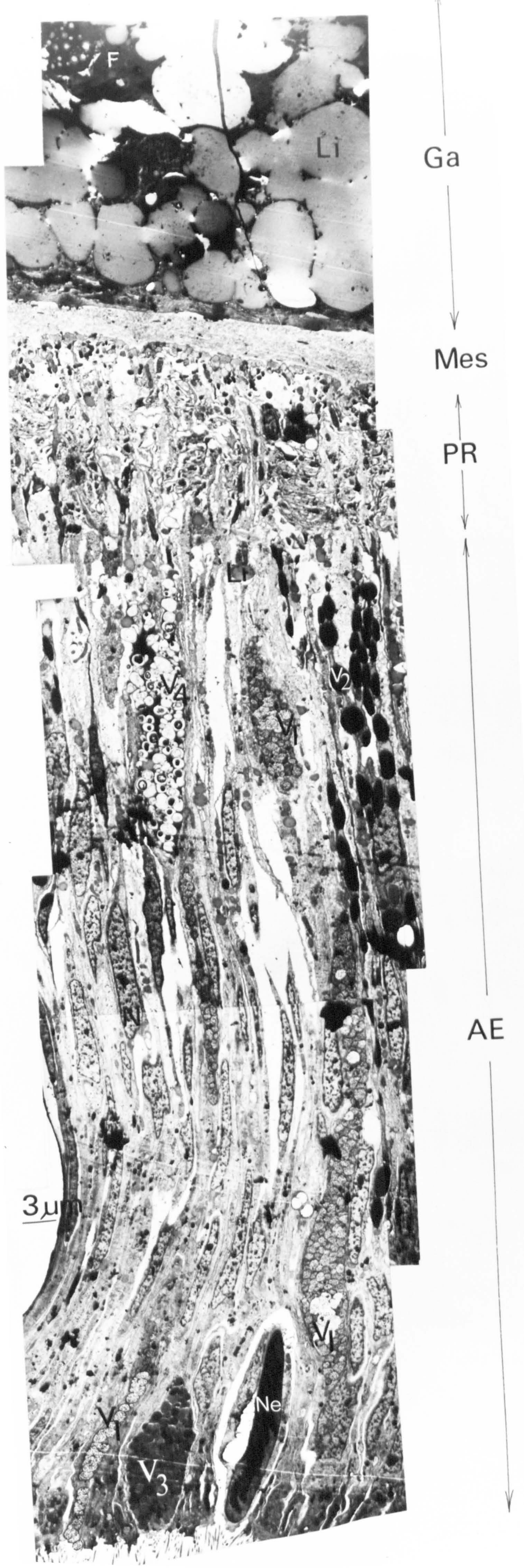
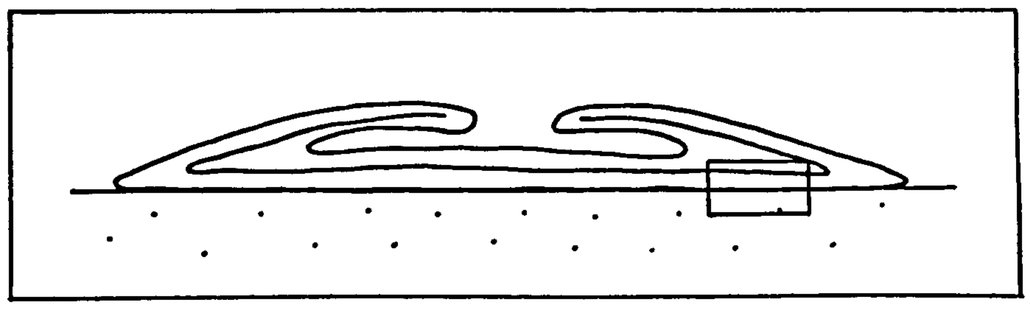

F
Li
L1
V4
V2
V1
V1
V1
V3
Ne
3µm
Ga
Mes
PR
AE

Figure 23

Vertical longitudinal section of a post-larval stage of Balanophyllia regia, which had been attached for five days, showing Type 2 vesicles (V_2) in the developing, prospective skeletogenic epithelium.



The five cell types which are still recognised are: Type 1 gland cells and nematocytes, neither of which is illustrated in this section and which do not occur frequently; Type 4 gland cells are only occasionally observed; epithelial cells are recognised by their lipid-like granules of intermediate electron density; and Type 2 gland cells, which contain electron dense vesicles (V_2), are very common. All these cells are flattened and interdigitate over their whole surface with each other.

The tensions produced during the cellular reorganisation of this epithelium has resulted in a disruption of the mesogleal region; spaces 2-3 μm wide are formed which appear to contain cellular debris (double ended arrow). The neurite layer is absent (cf. Fig. 17). Microfilaments extend from the proximal to the distal margins of the cells and are orientated parallel to their long axis. At this stage most cells have lost their cilia and microvilli; residual centriolar bodies have been observed in other sections. The intercellular spaces in this section are narrow (cf. Fig. 22), but they are a common feature of this epithelium. Mitochondria are common, particularly along the distal cell margins.

Ga: gastrodermis; IJ: intercellular junction; Li: lipid; Mes: mesoglear; MF: microfilaments; M: mitochondrion; N: nucleus; V_2,V_4: two Types of vesicle; YG: yolk granules.

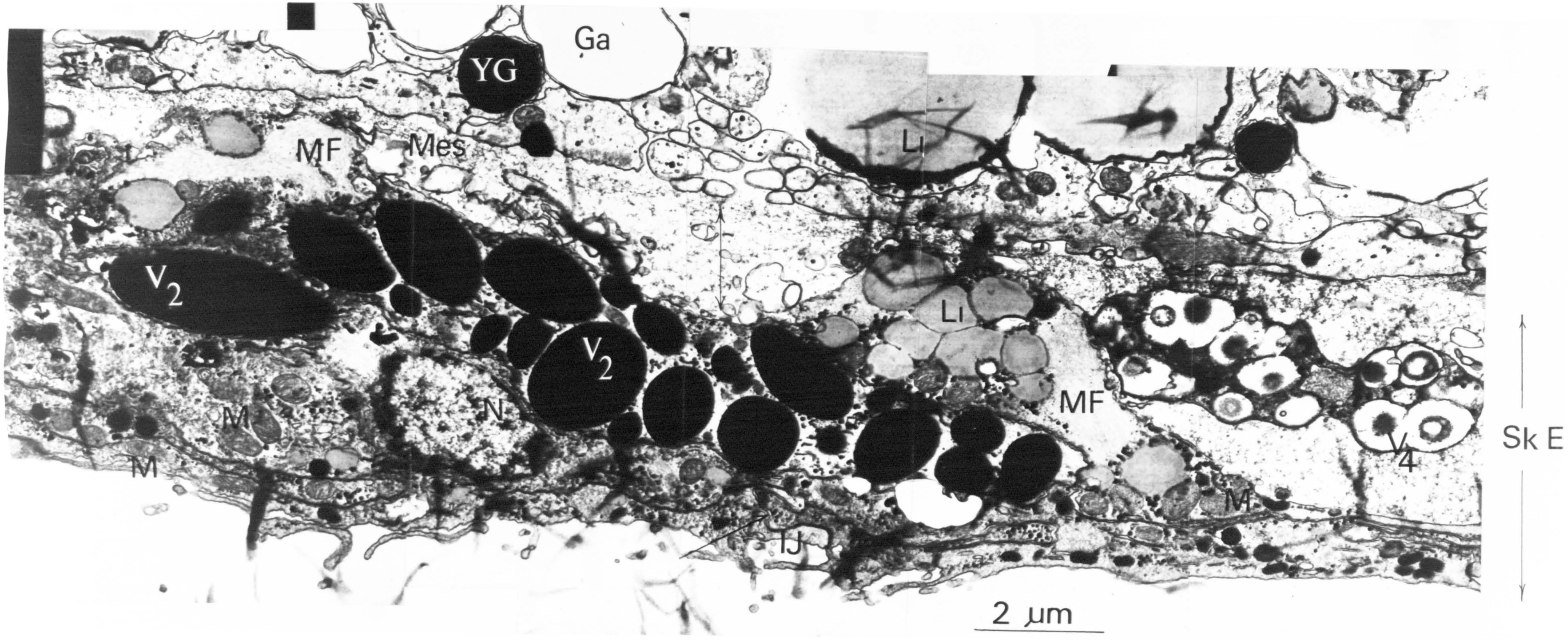
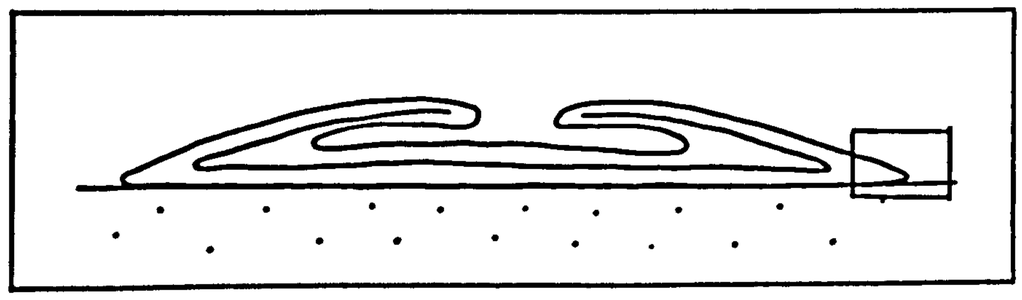

Ga
YG
MF
Mes
Li
V2
V2
Li
N
M
M
MF
V4
M
IJ
Sk E
2 µm

Figure 27

Vertical longitudinal section of a post-larval stage of Balanophyllia regia, which had been attached for six days, showing the lateral margin.



The lateral margin is approximately 130 µm wide and unattached to the substrate. A transition zone exists in which the outer arrangement and orientation of these cells is similar to that in the larval stage; whereas more centrally the cells are flattened and attached to the substrate. The cell movements in the lateral margin are not understood: they may 'slide' across each other before attaching and spreading. Fully developed Type 1 gland cells are common in this region and their secretions probably 'glue' the larvae to the substrate. Cilia and microvilli are absent from cells adjacent to the substrate but are present along the developing oral region.

Ci: cilium; FV: food vacuole; Ga: gastrodermis; Mes: mesoglea; N: nucleus; TZ: transition zone; V_1, V_2: two Types of vesicle.

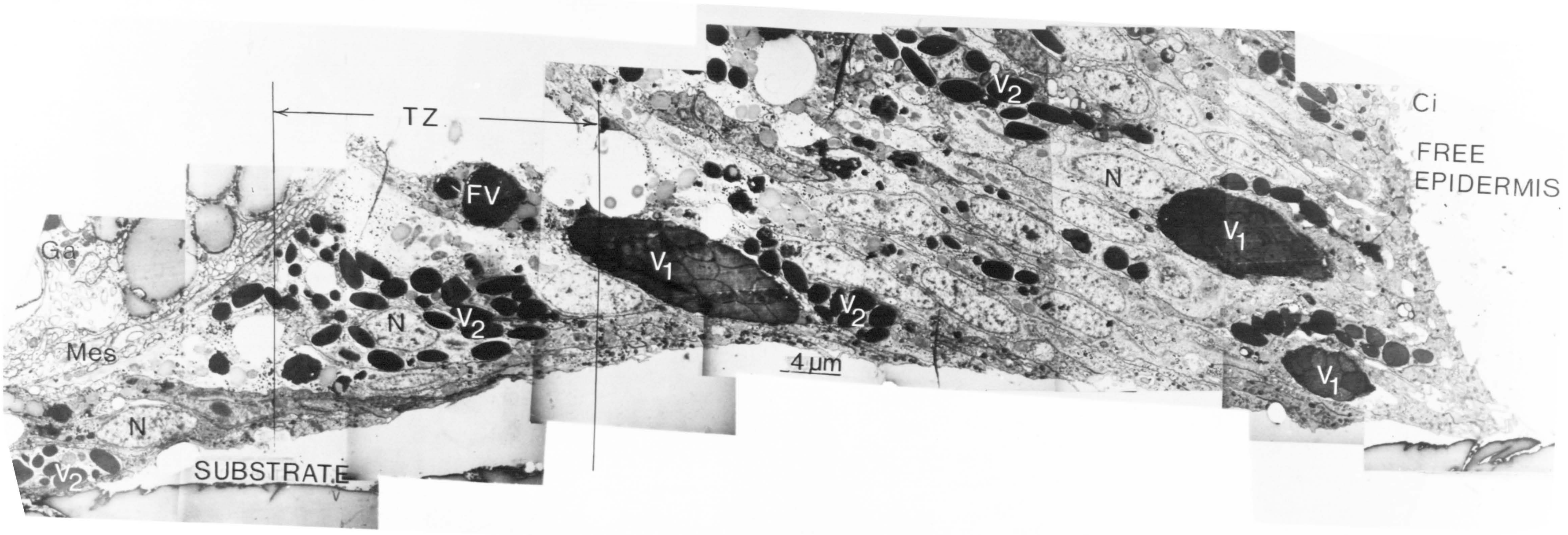
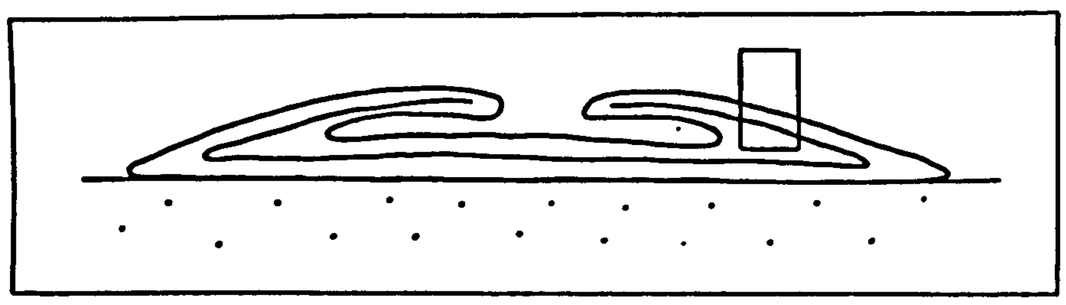

TZ
FV
Ga
N
V_2
Mes
N
V_2
SUBSTRATE
V_1
V_2
4 µm
N
V_1
V_1
Ci
FREE
EPIDERMIS

Figure 30

Vertical longitudinal section of a post-larval stage of Balanophyllia regia, which had been attached for six days, showing oral epidermis and gastrodermis.



Type 1 gland cells, are the most commonly observed secretory cells within the oral epidermis; their vesicles (V_1) form a 'goblet' shape typical of mucus cells, and their electron density decreases during the final developmental stages (cf. Fig. 31a). Gland cell Types 2 and 4 are also present but they are less common.

The gastrodermis contains three types of nutritive vacuoles: electron dense yolk granules (YG), 1-4 μm in diameter; sub-spherical electron opaque lipid vacuoles (Li), 0.5-10 μm in length, and heterogenous residual food bodies (FV)m 2-4 μm in diameter, which also are observed in the epidermis.

An electron dense fibrous material lines the junction of the gastrodermis with the mesoglea, myofilaments are present in the cells below this structure, and in places the musculature is more developed and invades the mesoglea.

FV: food vacuoles; Li: lipid vacuoles; Mes: mesoglea; Mu: musculature; N: nucleus; V_1,V_2,V_4: three Types of vesicles; YG: yolk granules.

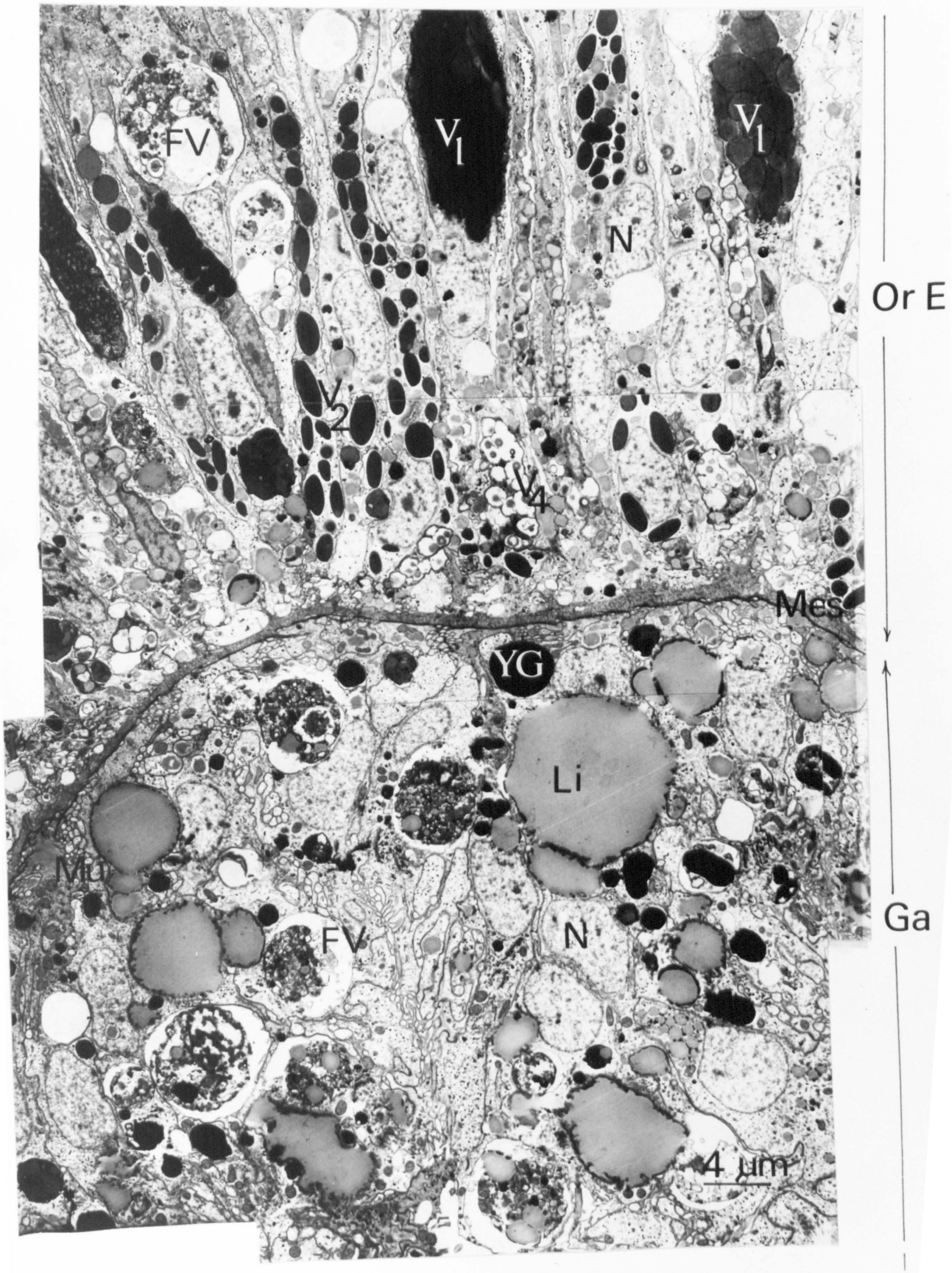
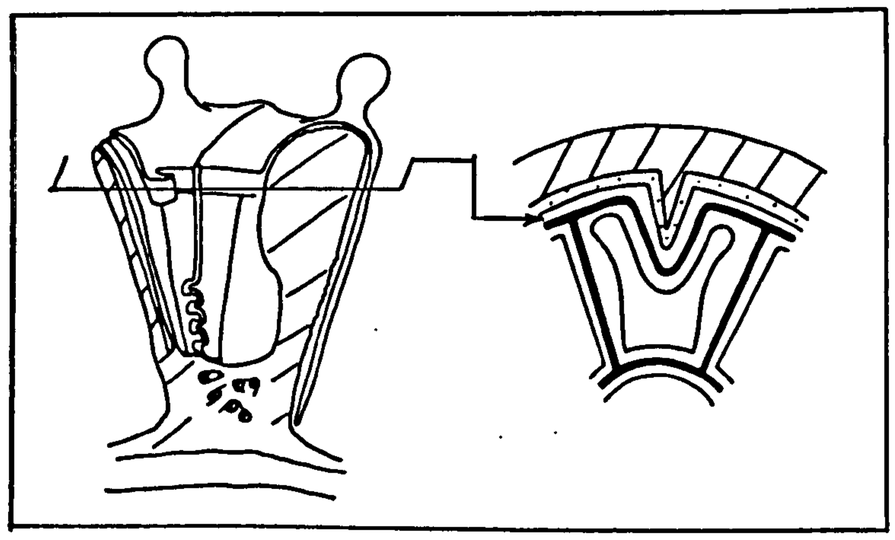

FV
V1
V1
N
V2
V4
Mes
YG
Li
Mu
FV
N
4 µm
Or E
Ga

Figure 55

Transverse section of the column of adult Caryophyllia smithi showing formation of secretory vesicles (SV_N).



The column is composed of three layers: the outer skeletogenic epithelium, separated from the gastrodermis by the intermediate mesoglea (cf. Fig. 65). The Golgi apparatus within the skeletogenic cells form secretory vesicles (SV_N) which contain a slightly electron dense granular substance; this increases in opacity during their development. Large intercellular spaces contain many membranous bodies (IB), some of which are released into the sub-epithelial space (at arrow). Many of these bodies are at least 1 μm in length and resemble membrane-bound cytoplasmic fragments (at double arrow). These may be similar to intercellular bodies which are present in the skeletogenic epithelium of post-larval stages of Balanophyllia regia (cf. Fig. 28). Intercellular junctions appear weak and structurally are more typical of septate junctions. Intracellular bodies of a whorled appearance, 1-2 μm in length, occur periodically; these may be cell breakdown products.

This specimen was not fed for 14 days before processing; consequently food vacuoles and glycogen granules are observed infrequently in this section.

G: Golgi; IB: intercellular bodies; IJ: intercellular junctions; MV: microvillus; M: mitochondrion; N: nucleus; Nu: nucleolus; RB: residual body; R: ribosomes; SV_N: secretory vesicles; W: whorls.

N.B. For figures 55 - 60 the orientation of the specimen is shown in the sketch beneath the title and should be compared with figures 62 and 65.

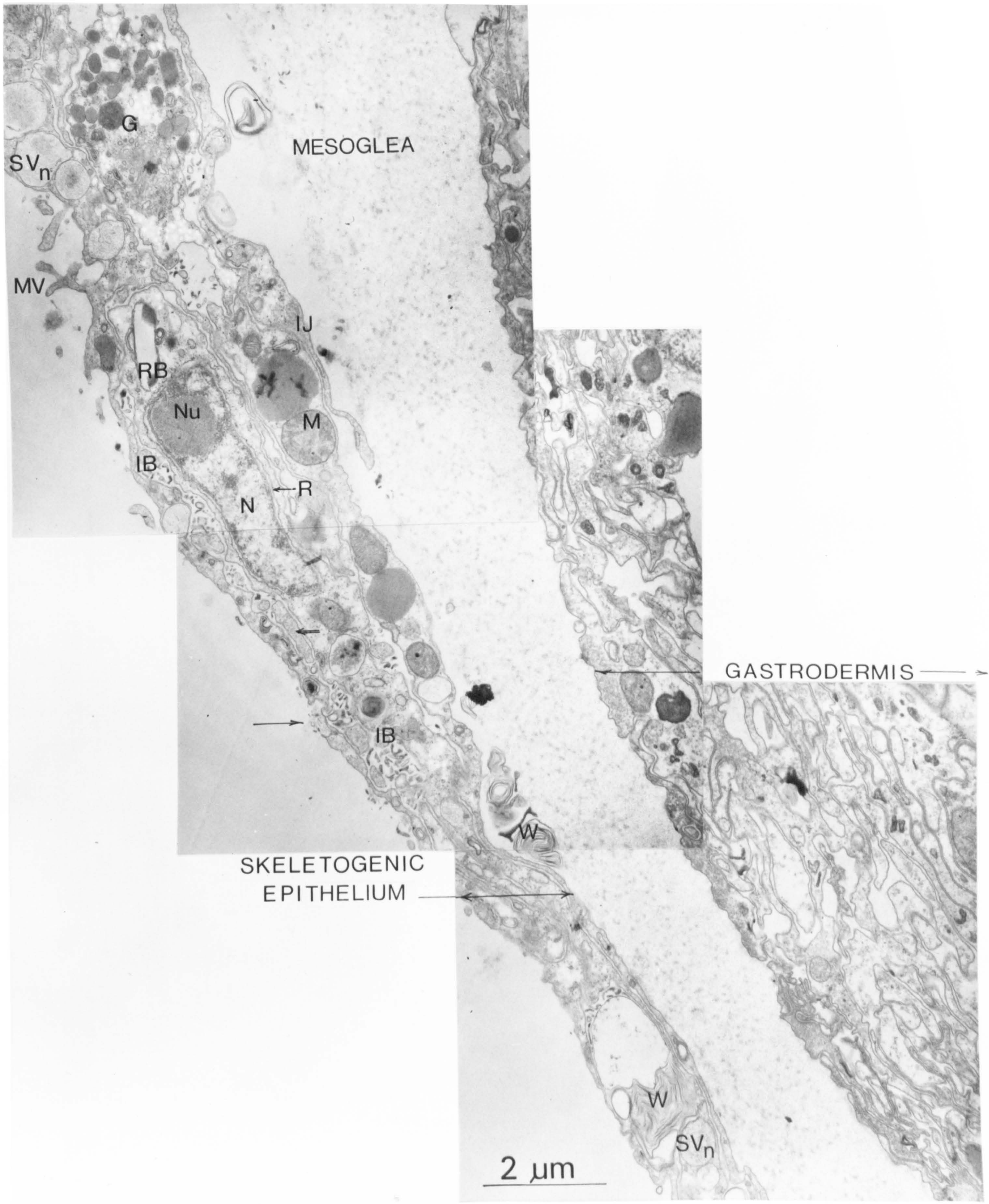
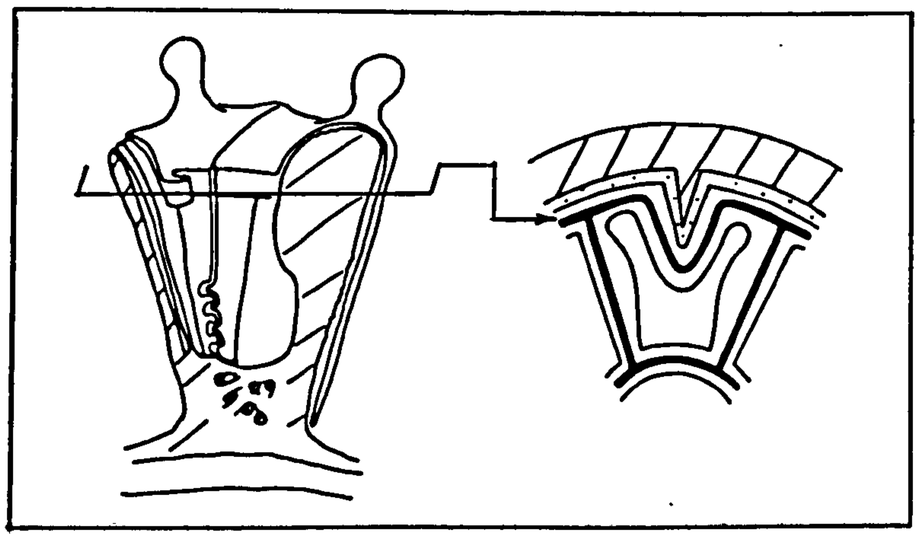

G
MESOGLEA
SVn
MV
IJ
RB
Nu
M
IB
R
N
IB
GASTRODERMIS
SKELETOGENIC
EPITHELIUM
W
W
SVn
2 µm

Figure 56

Horizontal section of the column of adult Caryophyllia smithi showing Type 2 vesicles.



Type 2 vesicles are not common in the skeletogenic epithelium of the adult; but when they occur their appearance is typical of those observed in larval and post-larval stages (cf. Fig.14b) Intercellular bodies are abundant along the proximal margin of the epidermis adjacent to the mesoglea; similar bodies are absent within the gastrodermis.

This specimen was fed regularly until it was processed; this is shown by the presence of large numbers of food vacuoles and glycogen granules in the gastrodermis and glycogen granules in the epithelium.

FV: food vacuole; Ga: gastrodermis; Gl: glycogen; IJ: intercellular junction; Mes: mesoglea; N: nucleus; SkE: skeletogenic epithelium; SV_N: secretory vesicle; V_2: Type 2 vesicles.

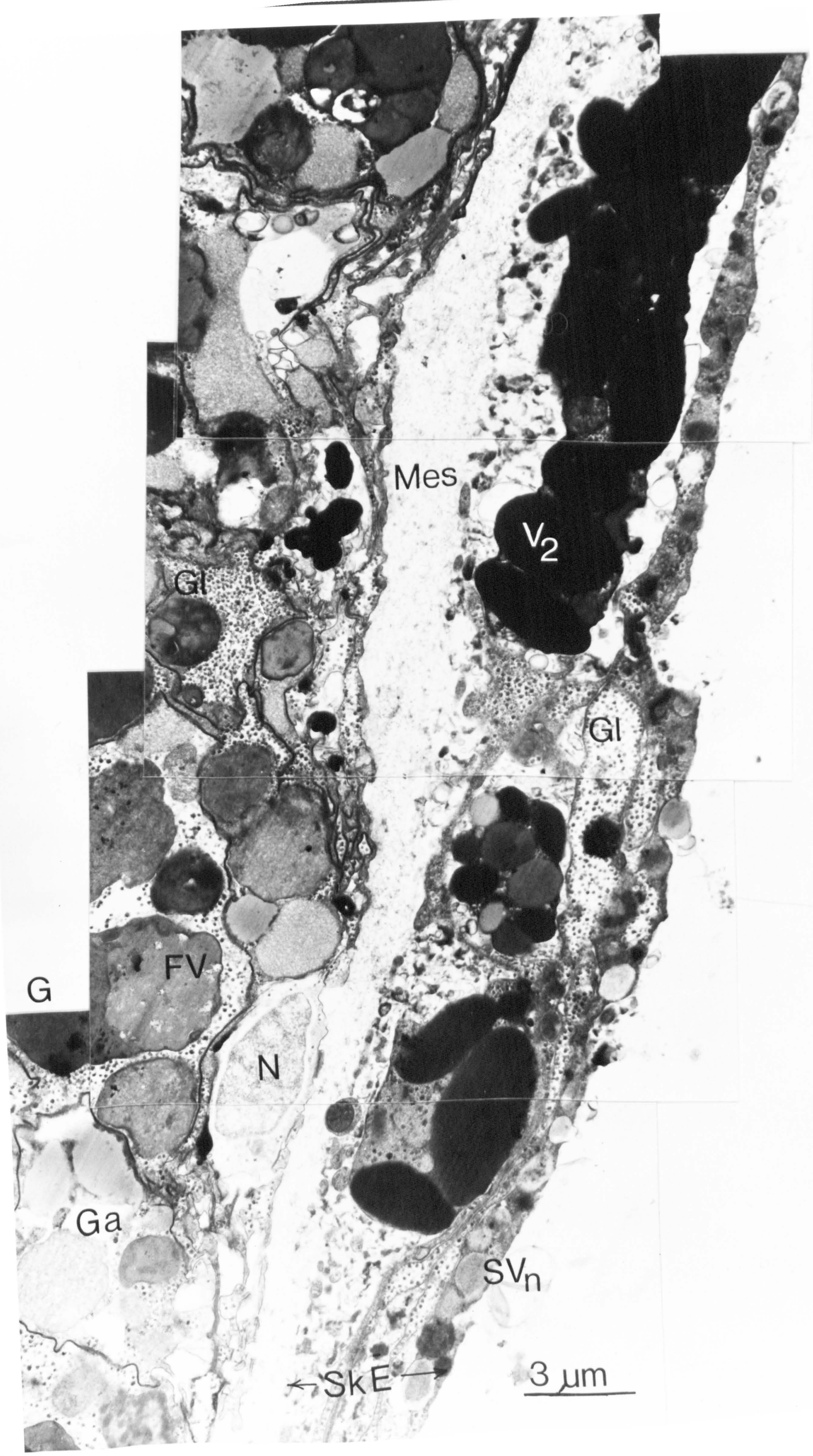
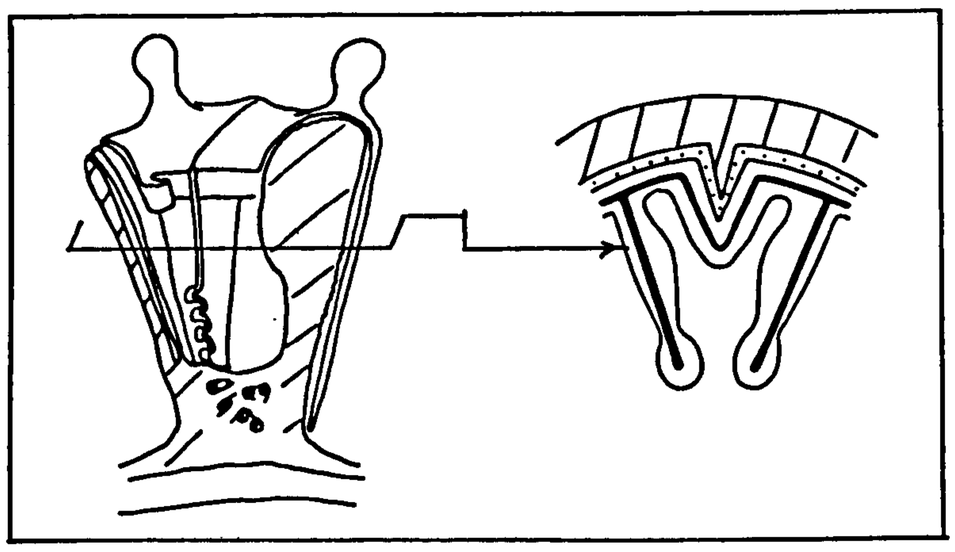

Mes
V2
Gl
Gl
FV
G
N
Ga
SVn
SkE
3 µm

Figure 67

Horizontal section of Caryophyllia smithi below the level of the pharynx showing mesenterial musculature.



The longitudinal retractor muscle, shown by the orientation of the myofilaments, is more pronounced than the circular transverse muscle; the former invades the mesoglea and in histological sections is described as mesenterial pleats (cf. Fig. 66c).

The musculature in this region of the polyp is strongly developed, as are the attachment processes of the column. Fibres within the ground substance of the mesoglea are mostly orientated vertically and tangentially to the oral-aboral axis of the polyp; occasionally dense banding of these fibres is observed across the mesoglea. The width of the mesoglea is variable; within the mesenteries it ranges from 10-20 µm and in the column it is as narrow as 0.5 µm, but it attains a width of 100 µm where attachment processes are formed (cf. Fig. 59).

Coel: coelenteron; FV: food vacuole; Gl: glycogen; RM: retractor muscle; TM: transverse muscle; Vac: vacuole.

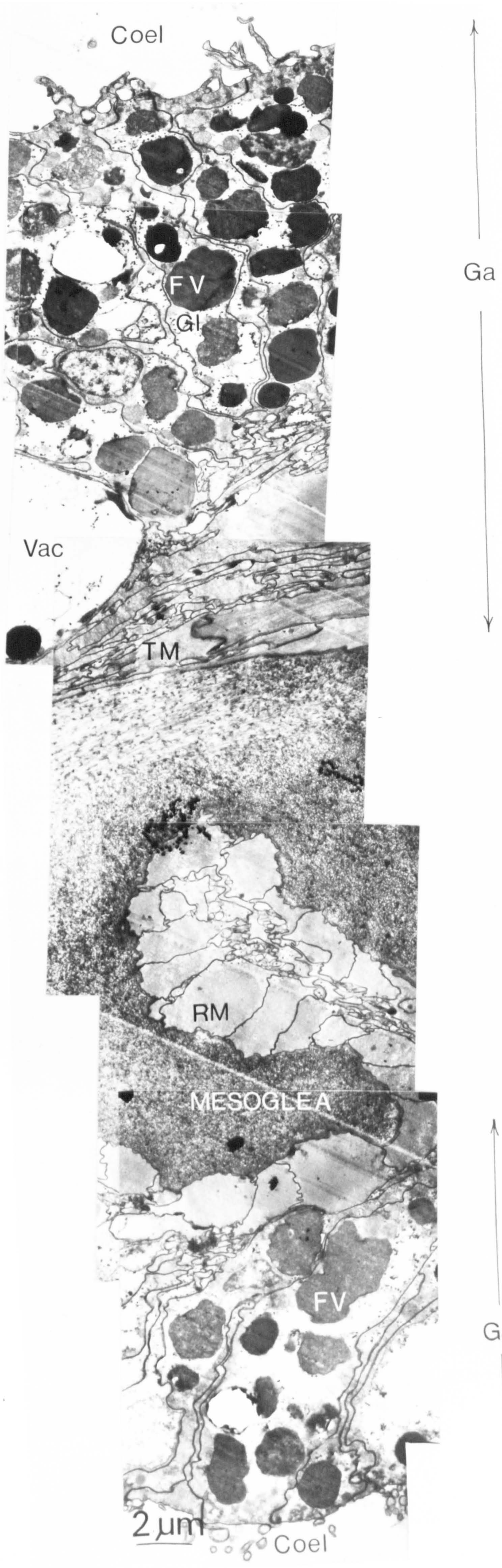
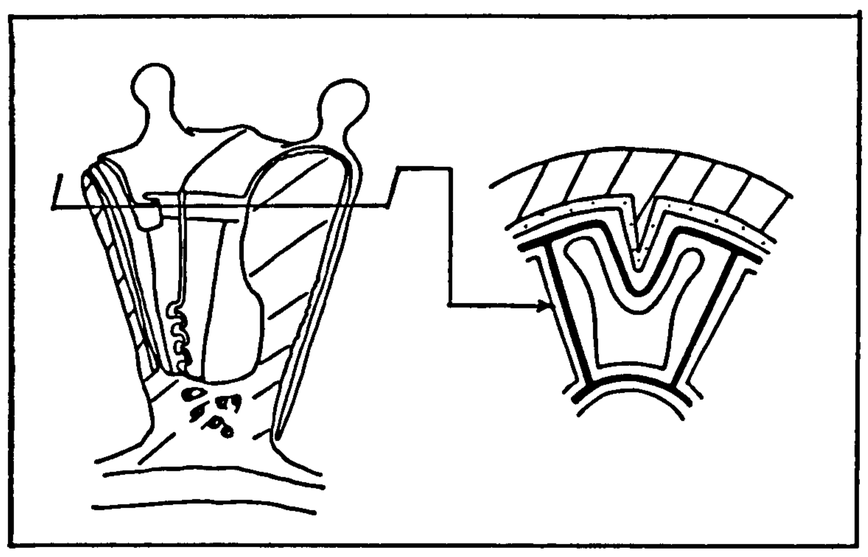

Coel
FV
Gl
Vac
TM
RM
MESOGLEA
FV
2 µm
Coel
Ga
Ga

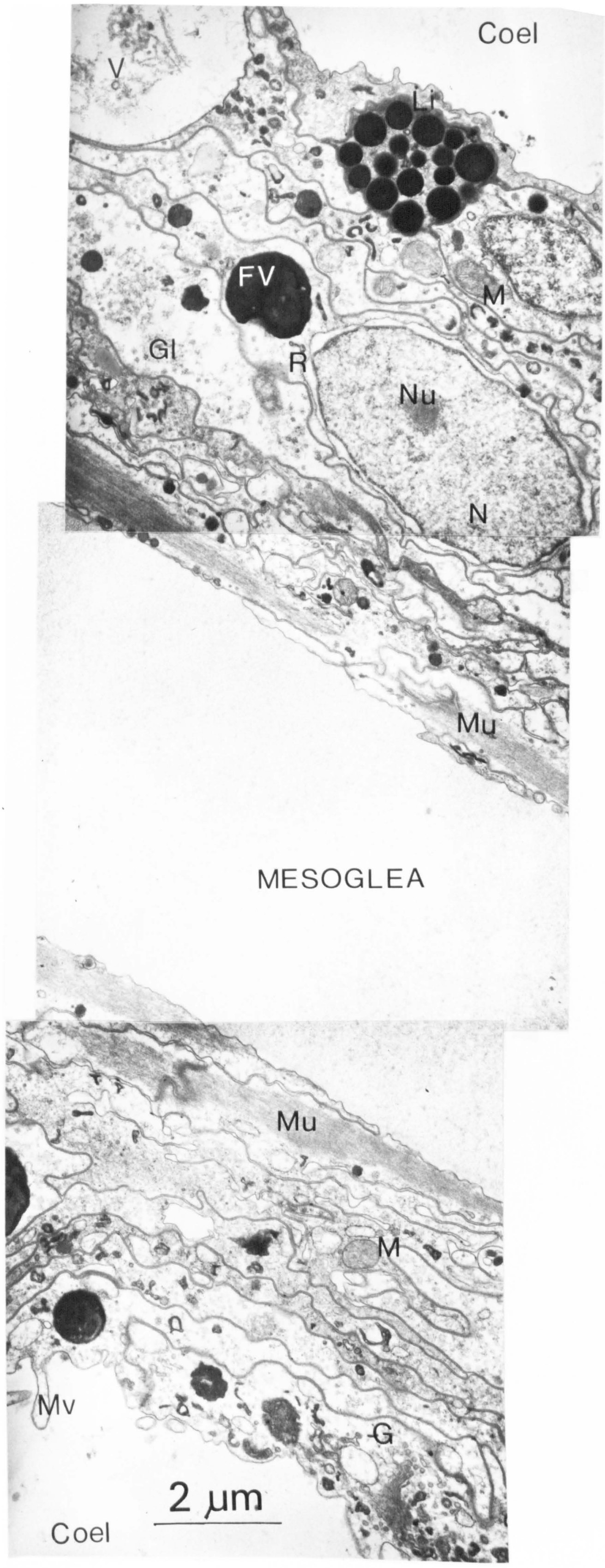
Figure 68

Oblique section of Caryophyllia smithi at the level of the pharynx showing poorly developed musculature within the mesenteries.



The gastrodermis is composed mainly of two cell types: columnar digestive (nutritive-muscular) cells, which are the most common, and elongate gland cells. The former are illustrated in the micrograph. This animal was not fed for two weeks before processing and both food vacuoles and secretory vesicles are sparse. Compared with Figure 67, the muscle bands illustrated in this section are poorly developed.

Coel: coelenteron; FV: food vacuole; Gl: glycogen; G: Golgi apparatus; Li: lipid; MV: microvillus; M: mitochondrion; Mu: muscle; N: nucleus; Nu: nucleolus; R: ribosomes; V: vacuole.


Coel
V
Li
FV
M
Gl
R
Nu
N
Mu
MESOGLEA
Mu
M
Mv
G
2 µm
Coel
Ga
Ga